THE PROBABLE FORMATION OF PHENOLIC COMPOUNDS BY A CHLORINATED WATER IN CONTACT WITH A COAL TAR PAINT

By C. A. Hechmer[1]

Hyattsville, Maryland, a suburb town near Washington, D. C., obtains its water supply from the northwest branch of the Anacostia River. Its water system is one of several in Maryland which are owned and operated by the Washington Suburban Sanitary Commission, an incorporated body, created by an act of the Maryland Legislature in 1918, to provide comprehensive water supply and sewerage facilities in the rapidly growing suburban towns contiguous to the District of Columbia, and within the limits of the State of Maryland.

The water supply for Hyattsville, until October, 1920, was obtained from seven driven wells. As the supply was inadequate, the Washington Suburban Sanitary Commission, after taking control of the system in January, 1920, immediately began work on 1,000,000-gallon rapid sand filtration plant, designed to serve the requirements of the immediate vicinity pending the construction of adequate works for the whole District. The plant was put into operation in October, 1921. The water treated at this plant is low in alkalinity and alum and soda ash are used in the treatment. The filtered water passes into a 100,000-gallon concrete reservoir which is built directly under the filtration plant, and is treated with liquid chlorine before leaving the plant. The chlorine is applied on the suction side of the high lift pumps, which force the water from the filtration plant into the distribution system and a 100,000-gallon elevated steel tank.

During the early spring of 1921, it became necessary to clean and paint the tank. Under the control of the Hyattsville town authorities the tank had been given no attention, with the result that the plates had scaled badly. Although the tank was known to be in poor condition when the Commission assumed control of the water

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system, the repairs were postponed until the old well supply had been abandoned and the new filtration plant placed in operation. The water from the wells had a high iron content causing a heavy deposit of iron sediment in the mains and in the tank. It was intended to clean the tank after the old source had been abandoned so that the iron sediment would not continue after cleaning. Because of the approach of cold weather when the filtration plant was completed, the repairs were further delayed until April, 1921.

The tank was first scraped and wire-brushed on the outside, and the entire container and tower were given two coats of outside steel paint. The riser was repaired in several places and the frost casing replaced and painted. On April 5 the tank was drained, the pumps being run during the hours when it was out of service. Fire hydrants were opened at several high points on the distribution system to relieve the excess pressure due to pumping against a closed distribution system. The tank was drained by 6.00 a.m. and the contractor immediately sent men into it to clean, scrape and wire-brush the inside, which work was completed on the first day. The surface was allowed to dry thoroughly over night and early the next morning the painters started to apply the base coat of paint. The exact composition of this paint was not determined, but the poor ventilation, together with the heat of the sun rays acting on the side plates, caused a disagreeable gas formation on the inside. As the day advanced the gas became stronger and by noon it became so strong that the painters were forced to discontinue work. Even with the aid of a canvas ventilator, which had been installed on top of the tank, the carrying off of the gas from the interior was ineffective. After sunset, the painters again went into the receiver and finished the first coat. On April 7, the second or final coat of paint was applied to the inside surface. This paint was applied hot. A vat was used to heat the paint on the ground and the hot paint was raised by means of ropes to the men in the tank. Analyses made later showed the composition of this paint to be probably a coal tar or asphalt product. The paint hardened quickly and the work was completed early in the afternoon. On the recommendation of the contractor, who also furnished the paint, the tank was put back into service within an hour after the painting was completed. As it had been painted from the top down, the paint in the bottom had little time to dry before coming in contact with the water when pumping was resumed. The entering water was treated with 0.4 p.p.m. of liquid

chlorine at the filtration plant. This dose had been applied to the water for several months previously with only occasional slight traces of taste in the tap water. The water entering the tank was further dosed with 1 p.p.m. of hypochlorite of lime as a measure of safety.

On the following day objectionable tastes and odors were present in the tap water, causing a flood of complaints from the consumers. The odor in the tap water closely resembled that of iodoform and the taste approached that of carbolic acid. With the exception of the dose of 1 p.p.m. of hypochlorite of lime and a marked reduction of atmospheric and water temperature during the filling of the tank, nothing unusual had taken place in operating conditions. The condition of the tap water was immediately attributed to chemical changes caused by the interaction of the new paint in the tank with the excessive dose of chlorine, or by the organic and iron deposits in the distribution system which had been stirred up when the hydrants were flushed during the pumping periods, while the tank was out of service. The distribution system was flushed as much as possible without endangering the water supply, but the taste and odor remained, although less in intensity.

The above facts were referred immediately to the Maryland State Department of Health. A report, to Mr. Robert B. Morse, Chief Engineer of the Washington Suburban Sanitary District, was prepared by Mr. Abel Wolman, Division Engineer of the Health Department, who advanced the following suggestions:

> It has been suggested that possibly there is some causal relationship between the unusual taste and the appearance of heavy suspended matter in the water. An examination of this latter material, however, in the presence of distilled water, gives no indication of unusual taste other than ordinarily obtaining in an iron bearing water, which is not objectionable from that standpoint. The addition of hypochlorite to this mixture, giving a dosage of 0.5 p.p.m., also resulted in no taste. There is little reason to suppose that this material, whose composition has been discussed in another memorandum submitted to you, should have any connection with the production of any unusual tastes or odors. I am inclined to believe that too much emphasis should not be placed upon this material as a causative factor, since the usual tendency is to ascribe objectionable tastes to the presence of matter which is physically apparent to the water user.
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> An examination of the paint used on the elevated tank gives much more evidence of where the responsibility for the taste should be placed. A sample of this paint was furnished by Mr. C. A. Hechmer. Its exact composition is unknown, but our qualitative laboratory tests indicate that it is probably a coal tar or asphalt product, containing phenols or cresols of various compositions. A small piece of this hardened paint was left in contact with distilled

water for a little over 15 minutes. In this time the water had taken up sufficient substance from the paint to impart to the water a decidedly disagreeable and characteristic taste of phenol. This taste made its appearance without any addition of hypochlorite. The character of the taste was modified and intensified by the further addition of 0.5 p.p.m. of hypochlorite to the water. Both of these solutions were tested for the presence of phenol after being in contact with the paint for two days. Both gave distinctly positive reactions. In the first case the color was the characteristic orange yellow in the presence of phenols, while in the second the reddish color, produced by the presence of higher phenols due to the combination with hypochlorite, was obtained.

A sample of the water from the elevated tank at Hyattsville, which had been in contact with the paint for 12 days, was tested also for phenols. The test was positive, but indicated approximately somewhat less than 0.5 p.p.m. of phenol. This water tasted, however, rather markedly of carbolic acid and coal tar products. Another sample obtained from the drug store at Hyattsville on April 19, gave a positive phenol tast which was weaker, however, than that of the sample taken directly from the tank. The color test for phenol in this sample was positive but very faint, probably in the neighborhood of one part in ten million.

Samples collected on April 21, from near the bottom and at the surface of the elevated tank showed in the first case a slight taste and in the second a more decided taste of phenol. In both instances, however, the intensity was considerably less than in previous samples.

The taste and odor remained in the water for some time after the painting of the tank, becoming weaker each day and finally disappearing at the end of about two weeks. The entire distribution system was flushed several times, and mains near the tank were flushed daily, until the taste and odor had disappeared entirely from the water.

The following combination of circumstances were advanced by Mr. Wolman as being responsible for the trouble from taste and odor in the tap water:

a. The use of a coal tar paint, some of whose constituents are soluble in water.

b. The placing in service of the freshly painted elevated tank, probably before the paint had hardened.

c. The use of 1 p.p.m. of chlorine within the tank in addition to a dosage of 0.4 p.p.m. in the water before it reached the tank.

d. The low temperature of the water supply.

These hypotheses were substantiated by the fact that the organic and iron deposits still persist in the tap water after the taste and odors, caused by the phenolic compounds liberated by the coal tar paint in the tank coming in contact with the chlorinated water, have entirely disappeared from the tap water.